A Floating Farm for Hydroponic Crop Cultivation and Food Security
Hydroponic Farming in the Aztecs of Central American

A Thesis Prospectus
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Bachelor of Science in Systems Engineering

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem: Switching to a Better Method of Farming

How can hydroponic farming combat issues faced by current methods of farming?

Ongoing effects of climate change and urbanization are causing growing problems for current methods of farming across the globe. These issues span from lacking space and resources to climate induced natural disasters, making cities, small islands and refugee camps some targets for new agricultural methods. My Systems and Civil Engineering Capstone team are working to improve a farming method to combat problems faced in Dominica. Like all small island developing states, Dominica holds a minimal percent of the world's population but is very susceptible to climate change influences such as natural disasters. Over the last four years, numerous capstone groups have been working to develop an efficient hydroponic farming system to survive hurricanes, floods and tropical storms. Specifically, this hydroponic system is an almost completely self-sufficient sustainable food source that will be built to withstand extreme weather and associated hazards and provide supplementary power supply when necessary. Our capstone group will add to (and finish) this hydroponic system, ensuring systematic protection during natural disaster activities that often hit these areas.

Hydroponic farming has been around for a long time, and has been used in many different historic civilizations. Although it seems like a promising method of farming given our world's current shortcomings, it has not stuck around in any area as a common method. To help understand potential uses for my Capstone team's hydroponic system, I hope to explore a place where hydroponic farming has been utilized for my STS project. Specifically, this STS research will look into the ancient use of hydroponics at the floating gardens of the Aztecs of Central America. I will evaluate the benefits and shortcomings of this method and consider its possibility and alignment in today's world.

Creating a Hydroponic Farm for use in Small Island Developing States (Technical)

Can we create a hydroponic system to survive Dominica's climate induced natural disasters?

Worldwide, some of the most at-risk regions for food insecurity are coastal communities and Small Island Developing States (SIDS) (i.e. nations in the Caribbean, Pacific, and Indian Ocean) due to a variety of natural and economic factors. Making up approximately 1% of the global population, SIDS face unique challenges due to their small land area, remote geography, and susceptibility to extreme climate events. Current food systems in place face mounting pressures from population growth, availability of fertile soil as well as an increasing rate of extreme weather. According to the UN, climate change is projected to negatively impact the four pillars of food security – availability, access, utilization, and stability – during the 21st century. Climate change is exacerbating the current stresses on these pillars through increasing temperatures, changing precipitation patterns, and the increase in frequency, duration, and intensity of extreme weather events like floods, droughts, and hurricanes. The goal of my capstone group's project is to provide a functional product that helps create sustainable food sources in Caribbean SIDS where there are frequent high risk natural disasters such as hurricanes and floods. Specifically, this project will be a hydroponic farm. Furthermore, we will continue to build and finish a crop cultivation system that is a mostly self-sufficient sustainable food source, withstands extreme weather and associated hazards, and provides supplementary power supply when necessary.

According to the University of the Bahamas, global mean sea-level is currently rising at a rate around 3.6 mm per year, a rate that is especially detrimental for coastal communities that support tourism, fisheries, and agriculture industries in the region. Beyond rising sea-levels,

SIDS are also vulnerable to extreme weather events which have been exacerbated by the changing climate. In 2017, Hurricane Maria caused damages that amounted to more than 225% more than the annual GDP of Dominica. Agriculture plays a primary role in the economy of Caribbean nations with several nations having large agriculture sectors which contribute to upwards of 20% of their total GDP. Despite their large production capacity of agriculture, most countries in this region are highly dependent on food imports. Currently in the Caribbean, many rural households are small-scale farming operations or have some food production capabilities. These households often have a traditional attachment to the land and farming on it. Since these operations are independent, there is no larger small-scale farming system or organization in place. This project hopes to reduce local food instability by allowing local farmers from SIDS to increase their total in-country food production by increasing total resiliency from weather events.

The 2018-19 capstone team modified an existing hydroponic crop cultivation system to create the Fold-out-Farm for post-hurricane recovery in Small Island Developing States (SIDS), particularly in the Bahamas. The next three capstone teams, ranging from 2019-2022, modified the design to float and operate with solar panels. Figure 1 below shows the most recent design of the 'Fold-out-Farm'. The model is an 8x8 foot square platform that holds a hydroponic Dutch bucket system and electrical equipment. Trapezoidal storm doors fold inwards by 45 degrees, protecting the electrical and hydroponics systems (Boland et al., 2022, p. 3). My capstone will be

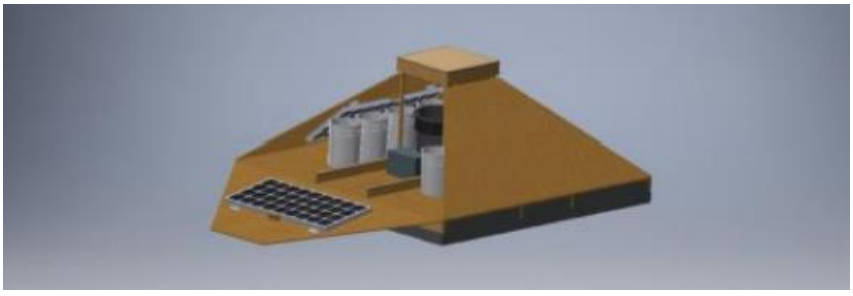

Figure 1: Floating platform AutoCAD model, partially folded: An overview of the current system depicting one of the trapezoidal panels unfolded. (Adapted by Ethan Thurmond from Boland et al. 2022)

building on the previous work of these teams by adding a rainwater harvesting or desalination system to the existing model so that a water supply is available for the crops in an emergency. Our group's initial idea for the rainwater collection system is a funnel that can filter rainwater, with the size of the funnel calculated by how much water the reservoir of the system can hold and how much water the system loses over time. Our second goal is to validate the feasibility of an hydroponic system under severe weather conditions such as hurricanes and strong winds. A computer-aided design (CAD) model is planned to be implemented to design an optimal model for resilience to strong weather conditions. Our third goal is to refine an existing market niche for systems through contacting stakeholders in SIDS and seeing where the demand for this product is strongest. If we develop a solution to these problems, and have enough time, we will then be able to look into which nutrient solution to use, as certain nutrient solutions can yield better harvests for certain crops (Singh et al., 2019, pp. 4-8).

If successful, we will have a product ready to enter the market for use in SIDS. We would have addressed any flaws in the previous system while adding the new modifications addressed above.

Hydroponic Farming in the Aztecs of Central America (STS)

How did hydroponic farming work as a sociotechnical system in the Aztecs?

From 1300 to 1521, the Aztecs had a flourishing Mesoamerican culture in central Mexico. Although severe drought and crop failure led to famine and deaths among their population, the Aztec had a unique and thriving farming culture for many decades. A type of hydroponic farm, Aztec Chinampas, also called floating gardens, were short stretches of elevated land in shallow water. This technique relied on "small, rectangular areas of fertile arable land to grow crops on shallow lake beds" ("Chinampas, The Ancient Floating Garden", 2021). Because this technique allowed for almost constant crop production, renewable soils and protection from frosts, this invention was known for its sustainable and productive qualities (Ebel, 1943). Similar methods have been used in different areas of the world throughout history, and are now coming back into discussion as a method for farming to combat issues such as climate change and urbanization.

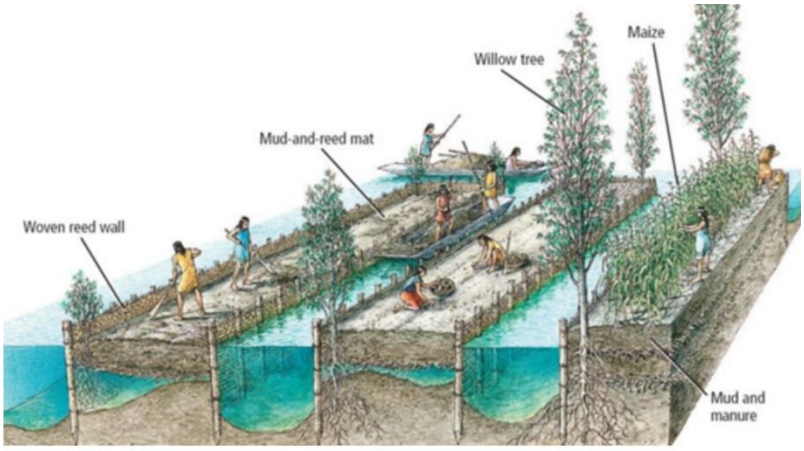

Figure 2: Aztec Chinampas ("Chinampas, The Ancient Floating Garden", 2021)

Aztec Farming Exploration, Background and Framework (STS)

For my research, I plan to explore Aztec hydroponic farming to understand how it could be used in today's society. I intend to fully understand the benefits, as well as the sociotechnical working of this farming method in the Aztec society. I will assess the required societal changes needed to implement this farming method, as well as its ability to combat issues of climate change and urbanization so I can determine its fit in today's world. This research will help my Capstone group understand the potential use cases of our hydroponic farm, as well as necessary

systematic and societal changes needed to implement this method among various groups and locations.

To understand potential drawbacks, I will look into why this method of farming was discontinued. I will analyze potential use from a negative perspective, and think of any cons as to why this method might not be beneficial in specific areas, or at all. I will consider actors in this network, such as farmers, the environment and developers of hydroponic farming, as well as government policy that aids farmers' implementation of this method from a societal standpoint in order to come to a conclusion regarding this method's potential benefit today.

Farming problems are especially common in certain parts of the world, such as small island developing states, refugee camps, and urban areas. All of these areas face different issues in regards to farming, but there is potential for hydroponics to benefit all of them. As I consider today's use of hydroponic farming, I will consider the possible changes to farming in all of these areas, to analyze where it would have the most benefit and the necessary changes for implementation.

Methods (STS)

In order to answer the questions above, I plan to assess research on the Chinampa farming method, via both first and second hand accounts of farming practices in the Aztecs. I will gather written models of Aztec farming methods to consider space taken and average output along with implementational and upkeep costs to make comparisons between Chinampa and conventional farming practices. Beyond these considerations, I will explore the needs of hydroponic caretaking from a sociotechnical perspective. I will use this information to consider how it will affect the jobs of farmers in both the transition to hydroponics along with the upkeep of this method. I will then consider potential use in the world today. Assessing both issues with

farming in areas such as small island developing states, urban areas and refugee camps, along with alignment of necessary societal changes for implementation will help me assess combativeness of hydroponic methods and where it could be most beneficial. This analysis will give me an idea of where this technology may be best implemented and most beneficial from a cultural, organizational and technical perspective.

Conclusion

My STS research will look into hydroponic farming in the Aztecs in order to gain understanding of how this method could benefit today's world. This research will be beneficial to our Capstone project, in which we are finishing a hydroponic farm for use in Dominica. After this hydroponic farm is created, my STS analysis will give me a much better understanding of the areas that need this type of technology, and how our system can be changed to benefit areas with different problems. I will understand the benefit of hydroponic farming, which will allow me to consider where it could be implemented in today's world, along with specific systematic and societal needs for creation and upkeep of the farming method. Overall, the mix of research towards benefits and needs of hydroponics along with the creation of a hydroponic farm for Dominica, will help me assess implementation of hydroponic technology in different areas of the world.

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